Emergency Brake System

Technical Field

The present invention relates to a vehicle emergency brake system for urgently avoiding collision of the vehicle.

Background Art

When a vehicle is traveling on a road surface having a low friction coefficient, such as a frozen road, a wet paved road, or a dry paved road where sand is disposed, the grip of the tires with respect to the road surface falls, so that the wheels tend to slip. Thus, heretofore, with a brake system for braking the rotation of wheels mounted on the vehicle (first brake means), even if hard braking is activated, the braking distance may increase excessively so that the vehicle may collide against an obstacle, irrespective of whether the vehicle is traveling at a high speed or a low speed.

On a road surface having such a low friction coefficient, since the degrees of slipping tend to be uneven for individual wheels, travel of the vehicle tends to be unstable, so that the vehicle may collide against an obstacle in an oblique direction. As means for allowing stable travel of a vehicle, such systems as an ABS (Antilock Brake System), which detects the degree of slip for every wheel and controls the braking force of each wheel, and VSC (Vehicle Stability Control) for controlling the engine output and the braking force of the wheels by detecting the steering tendency of the vehicle with a yaw rate sensor and a lateral acceleration sensor are used practically. But in order for these systems to operate effectively, it is a prerequisite that the grip of the tires remain to a certain extent.

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In order to avoid collision of a vehicle on a road surface having a low friction coefficient as mentioned above, apart from a conventional brake system, it is proposed to mount a second brake means for braking the vehicle in a short distance by increasing the frictional resistance with the road surface. As the second brake means, there are ones which spray slip-preventive materials such as sand and ice particles between the tires and the road surface (See for example patent documents 1 through 3.), ones in which a liquid adhesive is applied to the tire surfaces to stick slip preventive materials to the tires (See for example patent document 4.), ones in which thawing of the frozen road is prevented by blowing cold air on the tires (See for example patent document 5.), ones in which a braking plate or a toothed braking wheel is pressed against the road surface (See for example patent documents 6 through 8.), and ones in which the pressing force of the vehicle against the road surface is increased by inflating a gas bag outwardly of the vehicle (See for example patent document 9.), etc.

(patent document 1; unexamined JP patent publication 4-38204, patent document 2; unexamined JP patent publication 7-309101, patent document 3; unexamined JP patent publication 8-25905, patent document 4; unexamined JP patent publication 63-2706, patent document 5; unexamined JP patent publication 50-100703, patent document 6; unexamined JP patent publication 49-2228, patent document 7; unexamined JP patent publication 54-122528, patent document 8; unexamined JP patent publication 8-40222, patent document 9; unexamined JP patent publication 6-286586.)

Disclosure of the Invention

Once the above-described second brake means is actuated, it takes a

long time until it returns to normal, or it can never return to normal. Thus, it is desired to avoid unnecessary actuation and to actuate it only in an emergency where its actuation is indeed necessary.

Therefore, an object of the present invention is to provide an vehicle emergency brake system which can accurately actuate the second brake means.

In order to solve the above object, the vehicle emergency brake system comprises a first brake means for braking the rotation of a wheel, a second brake means for braking the vehicle by increasing frictional resistance with a road surface, an obstacle detector means for detecting an obstacle existing in an advancing direction, and a collision determination means for determining whether or not the vehicle is going to crash into an obstacle detected by said obstacle detector means by a vehicle speed and deceleration detector means, wherein when it is determined that the vehicle is going to crash by said collision determination means, said second brake means is actuated.

As the obstacle detector means, it is possible to employ a method in which reflective waves off an obstacle of a laser, visible light, infrared beams, millimeter waves, radio waves, electromagnetic waves such as magnetism, or elastic waves such as ultrasonic waves, or something generated by the obstacle itself are detected by a sensor, a radar, a TV camera, etc., a method in which emission waves of such electromagnetic waves or elastic waves are beacons, a method in which incoming waves are stereo-viewed or image-processed, or a method in which the GPS (Global Positioning System) or VICS (Vehicle Information Communication System) is used.

As the collision determination means, it is possible to use a method

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in which calculation is made as to whether or not the vehicle is going to crash into an obstacle detected by the obstacle detector means from the distance between the obstacle and the vehicle and the vehicle speed and acceleration or deceleration.

A hard braking detector means for detecting the actuation of hard braking by said first brake means or actuation requirements for hard braking by a driver may be provided so that if said actuation of hard braking or said actuation requirements are detected, determination is made on whether or not the vehicle is going to crash by said collision determination means. Thus, it is possible to reliably actuate the second brake means in an emergency.

The vehicle emergency brake system may further comprise a hard braking booster means for automatically boosting hard braking carried out by a driver through said first brake means so that if it is determined that the vehicle is crashing into an obstacle by said collision determination means, said hard braking booster means is actuated, and if it is determined that the vehicle is still going to crash into the obstacle, said second brake means is actuated. Using the hard braking booster means, it is possible to reduce situations in which actuation of the second brake means is necessary.

In an arrangement wherein said second brake means may comprise a plurality of different types, wherein a road surface condition detector means for detecting the condition of a road surface is provided, and wherein according to the road surface condition detected by the road surface condition detector means, said second brake means is selected from among the plurality of different types, it is possible to actuate a more effective type of second brake means according to the road surface condition.

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That is, for example, a second brake means of the type that sprays sand between a tire and a road surface is effective for a frozen road, but on a dry paved road where sand is disposed, it rather promotes slip of wheels. Thus, by mounting a plurality of different types of brake means, and selectively using them, the second brake means can be effectively actuated according to various road surface conditions.

As the road surface condition detector means, as with the ones described in JP patent publications 7-112659 and 2002-120709, it is possible to employ a method in which the road surface condition is indirectly inferred from the relation between the total sum of the slip values of the individual wheels and the vehicle acceleration, or from the frequency response of transmission characteristics from road surface disturbance to wheel speeds, or a method in which the road surface condition is directly observed with e.g. a TV camera.

In an arrangement in which after the second brake means have been actuated, if there is no actuation of hard braking by said first brake means, and determination is made that crashing of the vehicle into the obstacle will be avoided by said collision determination means, or if determination is made that the vehicle is at a stop, actuation of said second brake means is stopped, it is possible to save redundant use of slip preventive materials such as sand and ice particles or cold air blown against a tire during actuation of the second brake means.

By producing an alarm sound when said second brake means is actuated, the driver and passengers can prepare themselves for e.g. collision during actuation of the second brake means. The alarm sound should be stopped when determination is made that collision of the vehicle has been avoided or when the actuation of the second brake means has

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stopped.

Since the vehicle emergency brake system comprises a first brake means for braking the rotation of a wheel, a second brake means for braking the vehicle by increasing frictional resistance with a road surface, an obstacle detector means for detecting an obstacle in an advancing direction, and a collision determination means for determining whether or not the vehicle is going to crash into an obstacle detected by said obstacle detector means by a vehicle speed and deceleration detector means, wherein when it is determined that the vehicle is going to crash by said collision determination means, said second brake means is actuated, it is possible to reliably actuate the second brake means in an emergency and avoid unnecessary actuation of the second brake means, which takes time to return to normal.

A hard braking detector means for detecting the actuation of hard braking by said first brake means or actuation requirements for hard braking by a driver may be provided so that if said actuation of hard braking or said actuation requirements are detected, determination is made on whether or not the vehicle is going to crash by said collision determination means. Thus, it is possible to reliably actuate the second brake means in an emergency.

The vehicle emergency brake system may further comprise a hard braking booster means for automatically boosting hard braking carried out by a driver through said first brake means so that if it is determined that the vehicle is crashing into an obstacle by said collision determination means, said hard braking booster means is actuated, and if it is determined that the vehicle is still going to crash into the obstacle, said second brake means is actuated. Using the hard braking booster means, it is possible to

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reduce situations in which actuation of the second brake means is necessary.

In an arrangement wherein said second brake means may comprise a plurality of different types of brake means, wherein a road surface condition detector means for detecting the condition of a road surface is provided, and wherein according to the road surface condition detected by the road surface condition detector means, said second brake means is selected from among the plurality of different types of brake means, it is possible to actuate a more effective type of second brake means according to the road surface condition.

In an arrangement in which after the second brake means have been actuated, if hard braking by said first brake means is not actuated, and determination by the collision determination means is made that crashing of the vehicle into the obstacle will be avoided, or if determination is made that the vehicle is at a stop, actuation of said second brake means is stopped, it is possible to save redundant use of slip preventive materials such as sand and ice particles or cold air blown against a tire during actuation of the second brake means.

By producing an alarm sound when said second brake means is actuated, the driver and passengers can prepare themselves for e.g. collision during actuation of the second brake means.

Brief Description of the Drawings

Fig. 1 is a schematic structural view of a vehicle on which is mounted a vehicle emergency brake system of a first embodiment, Fig. 2 is a schematic structural view showing a second brake means of Fig. 1; Fig. 3 is a flowchart showing an algorithm for actuating the vehicle emergency

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brake system of Fig. 1, Fig. 4 is a schematic structural view of a vehicle on which is mounted a vehicle emergency brake system of a second embodiment, Fig. 5 is a flowchart showing an algorithm for actuating the vehicle emergency brake system of Fig. 4, and Fig. 6 is a flowchart showing an algorithm for actuating a vehicle emergency brake system of a third embodiment.

Best Mode for Embodying the Invention

Below, based on Figs. 1 through 6, the embodiments of this invention are described. Figs. 1 through 3 shows the first embodiment. As shown in Fig. 1, this vehicle emergency brake system comprises a second brake means 1 for increasing the frictional resistance with the road surface by spraying a slip preventive material between the tires and the road surface, a radar 2 using millimeter waves for detecting any obstacle in front of the vehicle A, a pedal speed sensor 5 for detecting the step-in speed of a brake pedal 4 for actuating a first brake means (not shown) for braking the rotation of the respective wheels 3, and a controller 6 for determining whether or not the vehicle A is going to crash into an obstacle detected by the radar 2 if hard braking by the first brake means is activated, and if determined that it will do, activating the second brake means 1.

In the controller 6, the distance L to the obstacle, which is detected by the radar 2, and the step-in speed S of the brake pedal 4, which is detected by the pedal speed sensor 5, are input. A threshold S_T of the step-in speed S, which is used as a reference for determination of hard braking of the first brake means, is preset. While not shown, the vehicle speed V as detected by a vehicle speed sensor and the vehicle acceleration α as detected by a vehicle acceleration sensor 18 are also input in the controller 6.

As shown in Fig. 2, the second brake means 1 accumulates gas in an accumulator 8 with a pump 7, supplies the accumulated gas into a spray material container 11 in which is stored a slip preventive material through two solenoid valves 9 and 10, opens the respective solenoid valves 9 and 10 under the command from the controller 6 to spray the slip preventive material through a nozzle 12 provided in front of one of the wheels 3. A bypass path 13 provided between the solenoid valve 10 and the nozzle 12 is provided for a test in which confirmation is made that the nozzle 12 is not clogged and the second brake means 1 operates normally, by blowing gas only through the nozzle 12. While not shown, the solenoid valves 9 and 10, the spray material container 11 and the nozzle 12 are provided for each wheel 3. They may be provided only on the front wheel side, where the braking effect is large.

Fig. 3 is a flowchart showing the algorithm of the controller 6, which activates the vehicle emergency brake system. First, the controller 6 compares the step-in speed S, which is input from the pedal speed sensor 5 at short intervals, with the preset threshold S_T (Step 1), and if the step-in speed S exceeds the threshold S_T, it further checks if there is any obstacle on the radar 2 (Step 2), and if there is an obstacle, it calculates the braking distance L_B by the first brake means from the vehicle speed V and the vehicle acceleration (deceleration) α, which are input from the vehicle speed sensor and the vehicle acceleration sensor 18, respectively, by the following formula (Step 3).

$$L_B = V^2/(2\alpha) \qquad\qquad (1)$$

In Formula (1), the braking distance L_B is calculated with the deceleration by hard braking as a constant deceleration α. The braking characteristics by the first brake means may be grasped beforehand so as to

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correct the braking distance L_B, which is calculated by Formula (1), based on the braking characteristics.

Next, the calculated braking distance L_B is compared with the distance L to the obstacle detected by the radar 2 (Step 4), and if the braking distance L_B exceeds the distance L to the obstacle, it determines that the vehicle is going to crash into the obstacle. Thus, it opens the solenoid valves 9 and 10 to actuate the second brake means 1 (Step 5).

In this embodiment, actuation of hard braking by the first brake means is a prerequisite for actuating the second brake means. But if actuation requirements of hard braking by the driver are a prerequisite, there is a case in which no deceleration has started yet, and thus the estimation of braking distance L_B is impossible. In such a case, if for example the output of a sensor for detecting actuation requirements for hard braking exceeds a predetermined threshold, it preferably unconditionally determines that the vehicle is going to crash into the obstacle and activates only the second brake means 1. In this determination, the distance L to the obstacle L and/or the vehicle speed V may be additionally taken into consideration.

Figs. 4 and 5 show the second embodiment. As shown in Fig. 4, this vehicle emergency brake system is provided, besides the elements of the first embodiment, with a second brake means 16 for pressing a braking plate 15 against the road surface with a cylinder 14, and a TV camera 17 for observing the road surface condition in front of the vehicle A. According to the road surface condition observed by the TV camera 17, the second brake means 1 for spraying the slip preventive material and the second brake means 16 for pressing the braking plate 15 against the road surface are selectively actuated by the controller 6.

The controller 6 determines from the road surface images picked up by the TV camera 17 whether the road surface is frozen, wet or dry. As described above, the road surface condition may be indirectly inferred from the relation between the sum of the slip values of the respective wheels and the vehicle acceleration, or frequency response of transmission characteristics from road surface disturbance to the wheel speeds.

Fig. 5 is a flowchart showing the algorithm of the controller 6, which actuates the above vehicle emergency brake system. As with the one of the first embodiment, first, the controller 6 compares the step-in speed S, which is input from the pedal speed sensor 5 at short intervals, with the threshold S_T (Step 1), and if the step-in speed S exceeds the threshold S_T, it further checks if there is any obstacle on the radar 2 (Step 2), and if there is an obstacle, it calculates the braking distance L_B by the first brake means from the vehicle speed V and the vehicle acceleration (deceleration) α by Formula (1). The calculated braking distance L_B is compared with the distance L to the obstacle (Step 4).

If the braking distance L_B exceeds the distance L to the obstacle, it determines if the road surface shot by the TV camera 17 is dry or otherwise (Step 5), and if it determines that the road surface is dry, the second brake means 16 for pressing the braking plate 15 is actuated (Step 6). Otherwise, the second brake means 1 for spraying the slip preventive material is actuated (Step 7).

While not shown, in the vehicle emergency brake system of the third embodiment, in the controller 6 of the first embodiment, which is shown in Fig. 1, a brake assist system as a hard braking boosting means for automatically boosting hard braking carried out by the driver through the first brake means is mounted, and if the braking distance L_B calculated by

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Formula (1) exceeds the distance L to the obstacle detected by the radar 2, the brake assist system is actuated first, and if it still determines that the vehicle A is going to crash into the obstacle, the second brake means 1 is actuated.

Fig. 6 is a flowchart showing the algorithm of the controller 6 for actuating the vehicle emergency brake system of the third embodiment. In this flowchart, Step 1 in the first embodiment of Fig. 3 is omitted, and Step 41 for actuating the brake assist system, Step 42 for calculating the braking distance L_{B1} by the brake assist system, and Step 43 for comparing the braking distance L_{B1} with the distance L to the obstacle detected by the radar 2 are provided in the YES path between Step 4 and Step 5 to actuate the second brake means 1 if the braking distance L_{B1} exceeds the distance L to the obstacle.

If the hard braking booster means such as the brake assist system is provided, steps for actuating the hard braking booster means may be provided between the YES path between Step 1 and Step 2 in the flowchart of the first embodiment, shown in Fig. 3 so as to make determination on vehicle collision by calculating the braking distance L_B by boosted hard braking of the first brake means and comparing it with the distance L to the obstacle.

In the above embodiments, as the obstacle detector means, a millimeter wave radar was used, and as the hard braking detector means, a pedal speed sensor for the brake pedal was used. But these obstacle detector means and hard braking detector means are not limited to those of the embodiment, but various methods as described above can be employed. For the second brake means, too, anything that can increase the frictional resistance with the road surface may be used. That is, the above-described

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various means can be employed.